about 32 metres in the summer. In the case of strong winds there was no reversal in the first 32 metres.

In the case of Potsdam observations, it was found that the height of the reversal was less than 41 metres for light winds and greater for strong winds. In the case of light winds in summer, there is a maximum at midday at Potsdam, but it is smaller than the maximum which occurs at midnight.

It appears, as a result of these calculations, that a variation in K by an amount which fits in well with all the other known data concerning the turbulent motion of the air near the ground is sufficient to explain, both qualitatively and quantitatively, all the facts concerning the daily variation of wind velocity at different heights above the ground which are brought to light by Dr. Hellmann's observations.

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# *The Discharge of Gases under High Pressures.*

By L. Hartshorn, B.Sc., A.R.C.S.

(Communicated by the Hon. R. J. Strutt, F.R.S. Received September 28, 1917.)

## *Introduction.*

This work was undertaken, following up a suggestion made by Lord Rayleigh.[*] De St. Venant and Wantzel in 1839 stated, as a result of their experiments, that when gas was discharged through an orifice from a vessel in which the pressure was $p_0$, into one in which the pressure was $p_1$, then the rate of discharge was sensibly constant from $p_1 = 0$ upwards to $p_1 = 0{\cdot}3p_0$ or $0{\cdot}4p_0$, but then, as $p_1$ further increases, the discharge falls off, slowly at first, afterwards with great rapidity.

In 1885 Osborne Reynolds quoted some experiments which seemed to show that the flow remained constant from $p_1 = 0{\cdot}50p_0$ or $0{\cdot}53p_0$. He explained this by pointing out that the maximum "reduced velocity" occurs when the actual velocity coincides with that of sound under the conditions then prevailing, as then the effect of a further reduction of pressure in the recipient vessel cannot be propagated backwards against the stream. If $\gamma = 1{\cdot}408$ this argument suggests that for a nozzle ending abruptly at the narrowest part, the discharge reaches a maximum when the pressure in the recipient vessel falls to $0{\cdot}527p_0$ and then remains constant. Lord Rayleigh pointed out the importance of examining with more accuracy than has hitherto been obtained the extent to which this constancy of flow for different values of $p_1$ is true.

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[*] 'Phil. Mag.,' vol. 32, p. 178 (1916.)

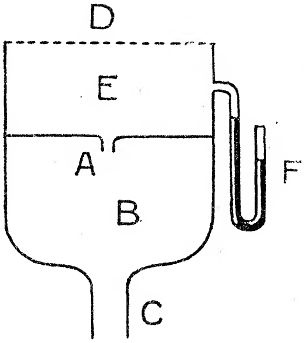

Fig. 1.

He suggested using for this purpose the arrangement indicated diagrammatically in fig. 1. A is the nozzle, B the recipient vessel, which is partially exhausted. The passage D from the external air to the discharging vessel E is somewhat choked and thus the reading of the pressure gauge F is a measure of the discharge. The discharge is absorbed by a powerful air-pump, communicating with B by the passage C. If the flow remain constant in spite of variations in the pressure in B, then the reading of F will remain constant.

### *Details of Apparatus.*

The details of the actual apparatus used are shown in fig. 2. The nozzle A was fitted into a brass tube a little more than a centimetre in diameter. The receiving vessel B and the discharging vessel E were made out of glass tubing 4 cm. in diameter. The brass tube holding the nozzle was fitted into these by means of rubber corks. The pressure in B was measured by means of the straight manometer tube H and the barometer tube K. The difference

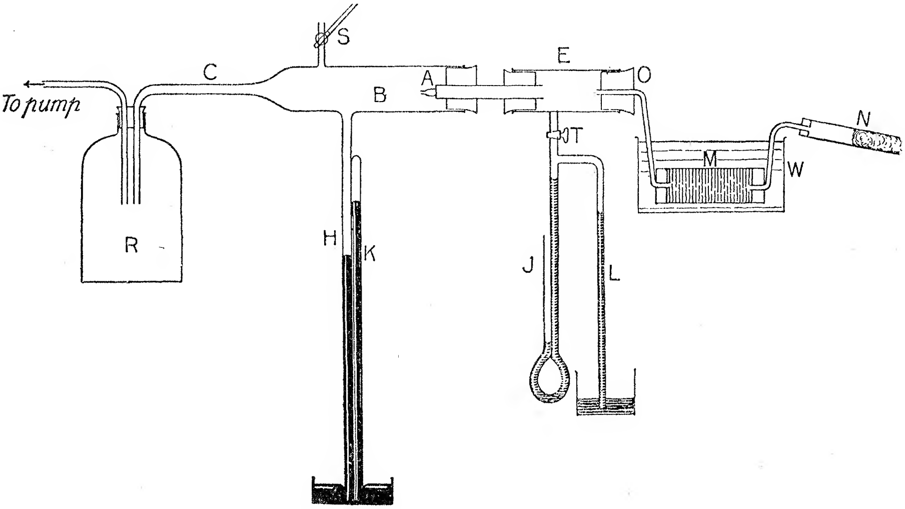

Fig. 2.

between the pressure in E and the atmospheric pressure was measured by means of the oil-gauge J, which could be cut off by means of the tap T. The small variations in this pressure were measured by observing the meniscus of the oil in the tube L. The lower end of this tube dipped into a wide vessel of oil, so that for small variations the whole change was shown by the change in level of oil in the tube. These changes were measured by means of a microscope having a scale in the eyepiece.

M is a cylinder of thin brass, 23 cm. long and of 5 cm. diameter. It was tightly packed with discs of copper gauze, which completely filled the tube. It was placed in a large bath of water W at the temperature of the laboratory, and was connected to the entrance of the discharging vessel by glass tubing fitting into rubber corks. The other end of this cylinder communicated with the glass tube N, which contained a plug of cotton-wool. Thus the air passed first up the tube N, then through the gauze in M into the discharging vessel E. It then passed through the nozzle into the receiving vessel B, and then to the pump through the large bottle R which served to steady the pressure in B. The choking at the entrance to E was supplied partly by the gauze in M and partly by the cotton wool in N. The latter also served to filter out the dust. The pump used was a Lennox vacuum pump driven by a 2 H.P. motor.

### *Preliminary Experiments.*

In the first experiments M and N were not used and the choking was supplied by a piece of capillary tubing fitting into the cork O. The nozzle in these experiments consisted of a thin brass plate with a small hole in it. This plate was soldered on to the end of the brass tube. Under these conditions accurate measurement was found to be impossible owing to the fact that the level of the oil in L was not steady even when the pressure in B was constant. The changes were of two kinds: (1) a slow regular fall of the meniscus, (2) rapid and irregular fluctuations of the level. The slow change was found to be due to the cooling effect at the nozzle. When the apparatus was left running for some time, this slow change gradually got slower and slower, and finally the mean position of the meniscus became constant, although the irregular fluctuations still persisted. When the brass nozzle was replaced by one drawn down from silica tubing, which has a very small coefficient of expansion, this slow change did not occur. The irregular fluctuations were, however, just as bad as they were with the brass nozzle. It was found that slightly warming the air entering E caused quite a considerable change of level in L, and this led to the suspicion that the irregular fluctuations were due to the non-uniformity of the air entering the apparatus.

The most probable source of any such temperature variation was the pump, which, although water-cooled, became warm after working for some time. Accordingly steps were taken to draw the air from the part of the room most remote from the pump. This was the purpose of tube N, which was of considerable length. A great improvement in the steadiness of the oil-gauge reading was obtained in this way. Additional improvement was obtained by the use of the cylinder of gauze M immersed in a large bath of water at the temperature of the laboratory. This served to mix the air thoroughly and to keep it at the room temperature. It should be mentioned that the oil fumes from the pump discharge were led into a fume cupboard, as, if by any chance they contaminated the air drawn through the apparatus, the result was condensation of oil in the nozzle. The air used was not specially dried.

### *Method of Performing an Experiment.*

Owing to the difficulty of making silica nozzles to an exactly predetermined shape, it was decided to use invar. The sample obtained had a coefficient of expansion larger than that of silica, so that the slow change in the oil-gauge reading, due to alteration in the size of the nozzle with temperature, was quite appreciable. Further there were also slight changes due to expansion or contraction of the manometer oil with slow changes in the room temperature. Any error due to this was avoided by proceeding as follows. The pump was set working so as to exhaust B as far as possible. The amount of choking was then adjusted, by varying the amount of cotton wool in N, until the reading of L reached a convenient value. The pressure in B was then slightly increased by opening the tap S, through which B communicated with the atmosphere. When the pressure in B and E had become steady, the tap S was closed, thus restoring the original low pressure in B. The level of the oil in L was continually watched by means of the microscope and any change noted. This was now repeated for a still higher pressure in B, and so on. In each case the pressure in B was restored to its original value, so that in each case the total change was measured, and as the change only occupied a few seconds, there could be no error due to slow change of level in L with temperature. Readings were taken until the change in level was too large to be measured on the microscope scale.

### *The Nozzles.*

The nozzles were all made out of a rod of invar, 8 mm. in diameter. They were soldered into a brass collar, which in turn was soldered into a length of brass tube. Thus it was quite easy to change from one nozzle to another.

The various shapes used are shown in fig. 3. No. 1 consists of a parallel hole of 0·8 mm. diameter and 7 mm. long. No. 2 is a parallel hole of about the same diameter, but only about 1 mm. long. No. 3 is really a hole in a thin plate, the edges being almost sharp. The remainder are all opened out similarly at the entrance end. No. 4 is cut off at the narrowest part. To make this a parallel hole was first bored, then one end opened out, and the other end ground down until the hole just began to get larger, the measurement of its diameter being made with the microscope. Nos. 5, 7, 8, 9, 10 and 11 end in divergent cones of angles 16·6°, 7·8°, 4·6°, 4·4°, 2·5° and 4·4° respectively. The length of the conical portion is about 2 cm. in each case. No. 6 ends in a parallel hole.

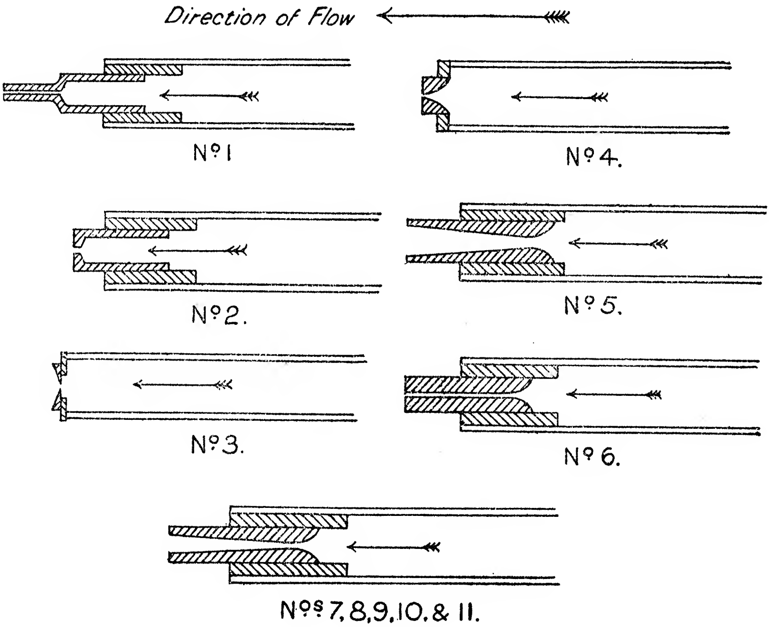

Fig. 3.

All the nozzles were tested to make sure of their being air-tight at the joints by closing the hole with the finger and blowing into the nozzle with the bellows, the end of the nozzle being under water.

The minimum diameter was in each case measured by means of the cathetometer microscope, using the eyepiece scale. In the case of nozzles ending in divergent cones the diameter at the base of the cone was measured in the same way, and the distance between these two diameters was obtained by measuring the distance through which it was necessary to advance the microscope in order to change the focus from one to the other. The angle of the cone was deduced from these measurements. The values are shown in Table I.

Table I.

| Nozzle. | Diameter at narrowest part. | Angle of cone. |
|---|---|---|
| | mm. | ° |
| 1 | 0·8 | — |
| 2 | 0·8 | — |
| 3 | 0·5 | — |
| 4 | 0·95 | — |
| 5 | 1·1 | 16·6 |
| 6 | 1·0 | 0 |
| 7 | 1·2 | 7·8 |
| 8 | 1·0 | 4·4 |
| 9 | 1·0 | 2·5 |
| 10 | 1·0 | 0·7 |
| 11 | 2·4 | 4·4 |

It has been mentioned that the chief source of trouble in the experiment was the unsteadiness of the reading of the oil-gauge, the irregular variations in particular. Further, we have seen that these were largely due to variations in the temperature of the air flowing through the nozzle. They were not entirely due to this, however, for the readings were much steadier with some nozzles than with others, other conditions being exactly the same. In no case were the readings perfectly steady. Nozzle No. 3 gave the best results, the variations in this case being very minute. No. 4 gave the least steady readings. The others were about equally good.

The scale in the eyepiece of the microscope had 50 divisions, and 30 of these corresponded to 0·1 inch (or 11·8 to 1 cm.). The pressure registered by the oil-gauge was about 17 inches (or 43 cm.) of oil in each case, so that one division on the microscope scale corresponded to about 0·02 per cent. of the whole pressure. Owing to the irregular variations mentioned above, it was not always possible to read the variations correct to less than one division on the microscope scale, though in nearly all cases it was possible to detect a total variation of half a division, and in many cases of less than this.

### *Results.*

The results are shown in Table II, where $p_0$ is the pressure in the discharging vessel. It is equal to the atmospheric pressure diminished by the pressure indicated by the oil-gauge. It is considered constant, as the variations in the oil-gauge reading are much too small to need taking account of in obtaining the ratio $p_1/p_0$; $p_1$ is the pressure in the receiving vessel, and is given by the difference of the readings of the mercury columns H and K (fig. 2). These readings were only taken correct to the nearest millimetre, further accuracy being unnecessary owing to the errors involved in making the other measurements. The readings on the microscope scale, shown in column 7, give the variations of the pressure $p_2$ indicated by the oil-gauge, and thus show the variations in the discharge of gas.

Table II.

| Nozzle. | Barometer reading. | Oil gauge reading. | $p_0$. | $p_1$. | $p_1/p_0$. | Microscope reading. | Corrected microscope reading. | $p_2$ (max. = 5000). |
|---|---|---|---|---|---|---|---|---|
| | cm. Hg. | | cm. Hg. | cm. Hg. | | scale divisions. | scale divisions. | scale divisions. |
| 1 | 75·3 | 18·85 | 72·3 | 5·1 | 0·071 | 0 | 0 | 5000 |
| | | ins. of oil | | 15·0 | 0·208 | 0 | 0 | 5000 |
| | | | | 19·1 | 0·264 | 0·3 | 0·3 | 4999·7 |
| | | 3·0 | | 23·5 | 0·325 | 1 | 1 | 4999 |
| | | cm. Hg. | | 25·2 | 0·348 | 1·7 | 1·5 | 4998·5 |
| | | | | 27·3 | 0·378 | 3·5 | 3 | 4997 |
| | | 5650 | | 30·1 | 0·417 | 10 | 9 | 4991 |
| | | mic. div. | | 32·4 | 0·448 | 25 | 22 | 4978 |
| | | of oil | | 33·8 | 0·468 | 38 | 34 | 4966 |
| 2 | 76·3 | 17·7 | 73·5 | 5·6 | 0·076 | 0 | 0 | 5000 |
| | | ins. of oil | | 12·6 | 0·171 | 0 | 0 | 5000 |
| | | | | 15·6 | 0·212 | 0·3 | 0·3 | 4999·7 |
| | | 2·8 | | 19·0 | 0·258 | 2 | 2 | 4998 |
| | | cm. Hg. | | 22·0 | 0·300 | 4 | 4 | 4996 |
| | | | | 24·9 | 0·339 | 8 | 8 | 4992 |
| | | 5310 | | 28·0 | 0·381 | 16 | 15 | 4985 |
| | | mic. div. | | 30·1 | 0·410 | 26 | 25 | 4975 |
| | | of oil | | 31·1 | 0·423 | 35 | 33 | 4967 |
| | | | | 32·3 | 0·440 | 48 | 45 | 4955 |
| 3 | 76·2 | 17·4 | 73·4 | 3·0 | 0·041 | 0 | 0 | 5000 |
| | | ins. of oil | | 12·9 | 0·176 | 0 | 0 | 5000 |
| | | | | 15·4 | 0·210 | 0·2 | 0·2 | 4998·8 |
| | | 2·8 | | 17·6 | 0·240 | 0·5 | 0·5 | 4999·5 |
| | | cm. Hg. | | 20·0 | 0·272 | 1 | 1 | 4999 |
| | | | | 22·3 | 0·304 | 2·5 | 2·5 | 4997·5 |
| | | 5220 | | 25·7 | 0·350 | 6 | 6 | 4994 |
| | | mic. div. | | 28·1 | 0·383 | 11 | 11 | 4989 |
| | | of oil | | 30·8 | 0·420 | 23 | 22 | 4978 |
| | | | | 32·3 | 0·440 | 34 | 33 | 4967 |
| | | | | 33·6 | 0·458 | 48 | 46 | 4954 |
| 4 | 76·7 | 17·7 | 73·9 | 9·0 | 0·123 | 0 | 0 | 5000 |
| | | ins. of oil | | 13·0 | 0·176 | 0 | 0 | 5000 |
| | | | | 17·4 | 0·236 | 1 | 1 | 4999 |
| | | 2·8 | | 19·5 | 0·264 | 2 | 2 | 4998 |
| | | cm. Hg. | | 22·5 | 0·304 | 4 | 4 | 4996 |
| | | | | 25·5 | 0·345 | 7 | 7 | 4993 |
| | | 5310 | | 28·5 | 0·386 | 13 | 12 | 4988 |
| | | mic. div. | | 30·5 | 0·413 | 22 | 21 | 4979 |
| | | of oil | | 32·7 | 0·443 | 37 | 35 | 4965 |
| | | | | 33·7 | 0·465 | 47 | 44 | 4956 |
| 5 | 76·4 | 17·7 | 73·6 | 11·2 | 0·152 | 0 | 0 | 5000 |
| | | ins. of oil | | 28·2 | 0·386 | 0 | 0 | 5000 |
| | | | | 30·9 | 0·420 | 0·3 | 0·3 | 4999·7 |
| | | 2·8 | | 33·3 | 0·452 | 1 | 1 | 4999 |
| | | cm. Hg. | | 36·0 | 0·490 | 4 | 4 | 4996 |
| | | | | 39·1 | 0·531 | 10 | 9 | 4991 |
| | | 5310 | | 41·6 | 0·565 | 23 | 22 | 4978 |
| | | mic. div. | | 43·1 | 0·586 | 33 | 31 | 4969 |
| | | of oil | | 44·0 | 0·598 | 43 | 40 | 4960 |

Table II—*continued.*

| Nozzle. | Barometer reading. | Oil gauge reading. | $p_0$. | $p_1$. | $p_1/p_0$. | Microscope reading. | Corrected microscope reading. | $p_2$ (max. = 5000). |
|---|---|---|---|---|---|---|---|---|
| | cm. Hg. | | cm. Hg. | cm. Hg. | | scale divisions. | scale divisions. | scale divisions. |
| 6 | 77·0 | 17·1 | 74·2 | 8·5 | 0·115 | 0 | 0 | 5000 |
| | | ins. of oil | | 13·3 | 0·179 | 0 | 0 | 5000 |
| | | | | 16·2 | 0·218 | 0·5 | 0·5 | 4999·5 |
| | | 2·8 | | 19·1 | 0·258 | 1·5 | 1·5 | 4998·5 |
| | | cm. Hg. | | 21·7 | 0·292 | 3·5 | 3·5 | 4996·5 |
| | | | | 24·4 | 0·329 | 7 | 7 | 4993 |
| | | 5130 | | 27·4 | 0·369 | 14 | 14 | 4986 |
| | | mic. div. | | 30·6 | 0·413 | 28 | 27 | 4973 |
| | | of oil | | 32·6 | 0·440 | 43 | 42 | 4958 |
| 7 | 75·5 | 17·35 | 72·7 | 12·9 | 0·178 | 0 | 0 | 5000 |
| | | ins. of oil | | 37·3 | 0·514 | 0 | 0 | 5000 |
| | | | | 40·3 | 0·555 | 0·5 | 0·5 | 4999·5 |
| | | 2·8 | | 43·3 | 0·596 | 1·5 | 1·5 | 4998·5 |
| | | cm. Hg. | | 46·3 | 0·637 | 4 | 4 | 4996 |
| | | | | 48·9 | 0·673 | 8 | 8 | 4992 |
| | | 5200 | | 51·2 | 0·705 | 15 | 14 | 4986 |
| | | mic. div. | | 53·6 | 0·737 | 27 | 26 | 4974 |
| | | of oil | | 55·4 | 0·762 | 46 | 44 | 4956 |
| 8 | 76·0 | 17·1 | 73·2 | 10·2 | 0·139 | 0 | 0 | 5000 |
| | | ins. of oil | | 56·1 | 0·766 | 0 | 0 | 5000 |
| | | | | 57·4 | 0·785 | 0·7 | 0·7 | 4999·3 |
| | | 2·8 | | 58·4 | 0·797 | 2·5 | 2·5 | 4997·5 |
| | | cm. Hg. | | 58·8 | 0·804 | 3·4 | 3·4 | 4996·6 |
| | | | | 59·2 | 0·809 | 5 | 5 | 4995 |
| | | 5130 | | 59·8 | 0·818 | 9 | 9 | 4991 |
| | | mic. div. | | 60·2 | 0·822 | 12 | 12 | 4988 |
| | | of oil | | 61·3 | 0·838 | 30 | 29 | 4971 |
| | | | | 62·0 | 0·847 | 46 | 45 | 4955 |
| 9 | 76·9 | 17·1 | 74·1 | 9·7 | 0·131 | 0 | 0 | 5000 |
| | | ins. of oil | | 55·6 | 0·751 | 0 | 0 | 5000 |
| | | | | 57·2 | 0·772 | 0·5 | 0·5 | 4999·5 |
| | | 2·8 | | 58·6 | 0·791 | 0·8 | 0·8 | 4999·2 |
| | | cm. Hg. | | 59·7 | 0·805 | 1 | 1 | 4999 |
| | | | | 60·4 | 0·815 | 1·5 | 1·5 | 4998·5 |
| | | 5130 | | 61·1 | 0·825 | 3 | 3 | 4997 |
| | | mic. div. | | 61·7 | 0·833 | 8 | 8 | 4992 |
| | | of oil | | 62·2 | 0·840 | 12·5 | 12·5 | 4987·5 |
| | | | | 62·7 | 0·846 | 32 | 31 | 4969 |
| | | | | 63·1 | 0·852 | 45 | 44 | 4956 |
| 10 | 76·8 | 17·0 | 74·0 | 9·5 | 0·128 | 0 | 0 | 5000 |
| | | ins. of oil | | 28·7 | 0·388 | 0 | 0 | 5000 |
| | | | | 30·5 | 0·412 | 0·8 | 0·8 | 4999·2 |
| | | 2·8 | | 32·0 | 0·433 | 1·7 | 1·7 | 4998·3 |
| | | cm. Hg. | | 33·6 | 0·454 | 4 | 4 | 4996 |
| | | | | 35·1 | 0·475 | 7 | 7 | 4993 |
| | | 5100 | | 36·7 | 0·496 | 11·5 | 11·5 | 4988·5 |
| | | mic. div. | | 38·6 | 0·522 | 22 | 22 | 4978 |
| | | of oil | | 40·5 | 0·547 | 39 | 38 | 4962 |
| | | | | 41·5 | 0·561 | 51 | 50 | 4950 |

Table II—*continued.*

| Nozzle. | Barometer reading. | Oil gauge reading. | $p_0$. | $p_1$. | $p_1/p_0$. | Microscope reading. | Corrected microscope reading. | $p_2$ (max. = 5000). |
|---|---|---|---|---|---|---|---|---|
| | cm. Hg. | | cm. Hg. | cm. Hg. | | scale divisions. | scale divisions. | scale divisions. |
| 11 | 76·3 | 17·6 ins. of oil<br>2·8 cm. Hg.<br>5280 mic. div. of oil | 73·5 | 49·2 | 0·670 | 0 | 0 | 5000 |
| | | | | 58·5 | 0·795 | 0 | 0 | 5000 |
| | | | | 59·6 | 0·811 | 0·5 | 0·5 | 4999·5 |
| | | | | 60·8 | 0·827 | 1 | 1 | 4999 |
| | | | | 61·5 | 0·837 | 3 | 3 | 4997 |
| | | | | 62·2 | 0·846 | 7 | 7 | 4993 |
| | | | | 62·8 | 0·855 | 14 | 13 | 4987 |
| | | | | 63·1 | 0·859 | 18 | 17 | 4983 |
| | | | | 63·7 | 0·866 | 38 | 36 | 4964 |
| | | | | 64·0 | 0·870 | 50 | 47 | 4953 |

In order to allow the results for various nozzles to be conveniently compared, the values of $p_2$ are given corresponding to the various values of $p_1$ expressed as a fraction of $p_0$, the maximum value of $p_0$ in each case being reckoned as 5000. Since the actual value of $p_0$ was not exactly 5000 microscope divisions, the microscope readings were corrected to make them correspond to this value.

Curves were plotted showing the relation between $p_2$ and $p_1$ for the various nozzles. They are shown in figs. 4 and 5.

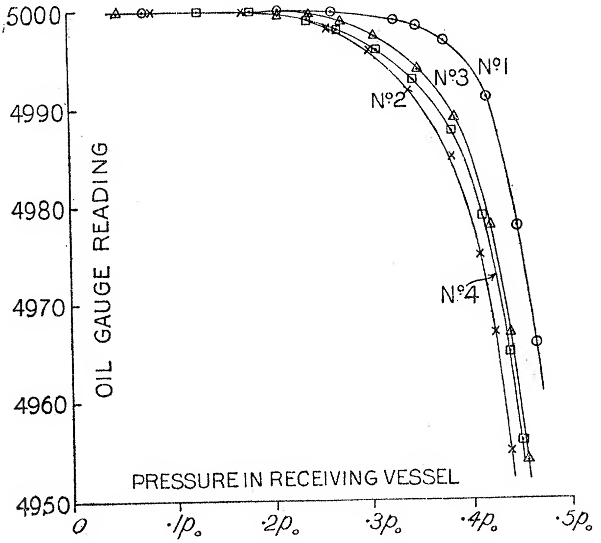

FIG. 4.

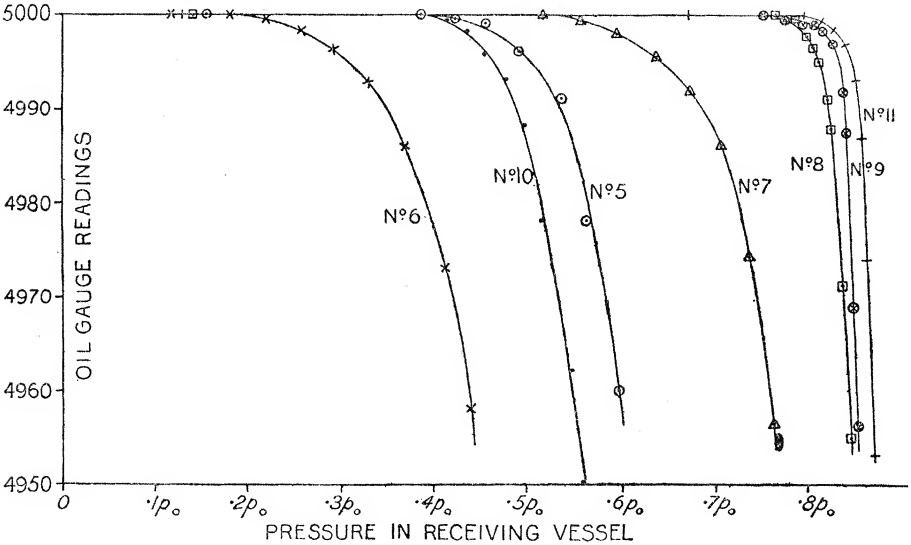

Fig. 5.

*Discussion of Results.*

It will be seen from the curves that the fact that the discharge is independent of the pressure in the receiving vessel, when this is less than a certain fraction of that in the discharging vessel, is amply verified by the experiments. In each case the flow was constant, probably to within 0·01 per cent., for a considerable range of $p_1$, the pressure in the receiver.

The experiments also show that we cannot accept the theoretical value of this critical pressure below which the flow from a convergent nozzle remains constant, viz., 0·527 $p_0$ as applying to all nozzles; indeed, we cannot accept any particular value as applying even approximately to all nozzles. In some cases the value is as low as 0·2$p_0$, and in others it is as great as 0·8$p_0$. The value 0·2$p_0$ holds very approximately, however, for all the nozzles tried except the divergent ones. Those ending in divergent cones all have higher values, and the value increases as the angle of the cone decreases from large values down to about 3°. In this case the critical pressure is about 0·8$p_0$. As the angle of the cone is further decreased the value of the critical pressure seems to decrease. For an angle of 0·7° it is about 0·4$p_0$, and when the angle becomes zero, *i.e.*, for a parallel hole, we obtain the value 0·2$p_0$.

It seemed possible that these results might be of practical importance in connection with turbine nozzles. Accordingly, in order to ascertain whether the phenomena were very considerably modified in nozzles of larger diameter, No. 11 was made with a diameter as large as the pump would allow. The flow of air was then so large that the cylinder of gauze M produced too much choking to give a convenient reading of the oil-gauge, and it had to be removed, so that the choking was then supplied by the tube connecting E and N (fig. 2) and a very small piece of cotton-wool in N. Even under these conditions the readings of the oil-gauge were fairly steady with this nozzle. The first reading of $p_1$ was of course not very low in this case, but it is seen to lie well on the horizontal portion of the curve. The result for the nozzle of larger diameter is seen to be practically the same as that for a smaller one of the same shape.

In conclusion I wish to thank Prof. the Hon. R. J. Strutt, F.R.S., for advice on many points, and for the keen interest he has taken in the work throughout its progress.

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# *On the Relation between Barometric Pressure and the Water-level in a Well at Kew Observatory, Richmond.*

By E. G. Bilham, A.R.C.Sc., D.I.C., B.Sc., F.R.Met.Soc.

(Communicated by Sir Napier Shaw, F.R.S. Received October 13, 1917.)

## I. *Introductory.*

The investigation which forms the subject of the present communication must be regarded as forming part of a general inquiry into the mode of action of the well at Kew Observatory, Richmond. The well was sunk during the course of some extensive alterations to the building about four years ago, and the water-level has been continuously recorded since the end of July, 1914. The mean level for each day expressed in centimetres above Ordnance Datum has been published in the 'Geophysical Journal,' and the extreme values for each month have usually been given in the Monthly Weather Report. After being in action for two years, it was thought desirable to undertake a somewhat detailed examination of the records which had accumulated. The most interesting feature of the inquiry proved to be the periodic variations of level, which were to be attributed to the tidal oscillations of the neighbouring River Thames. The most noteworthy response of the well was found in the case of the lunar fortnightly oscillation, which could, indeed, be plainly seen by merely plotting successive daily mean levels on a fairly open scale.

The solar and lunar diurnal, semi-diurnal, ter-diurnal, ..., oscillations were